Determination of Upper Limit of Stars Mass Based on Model of Expansive Nondecelerative Universe

Jozef Šima and Miroslav Súkeník

Slovak Technical University, Radlinského 9, 812 37 Bratislava, Slovakia

sima@chtf.stuba.sk

Abstract. Incorporation of the Vaidya metric in the model of Expansive Nondecelerative Universe allows to localize the energy density of gravitational field that, subsequently, enables to determine the upper limit of stars mass. The upper limit decreases with cosmologic time and at present is close to 30-fold of our Sun mass.

Introduction

In the stars two key contrary oriented energy-mass forces can be identified, namely the stream of radiation directing from the center to outside of a star, and the gravity attracting the star mass to its centre.

The central gravitational pressure p_g created by a star is proportional to the square of its mass m_s

$$p_g \sim m_s^2 \tag{1}$$

Providing that, in general, the chief process of mass transformation and energy formation in stars is a standard reaction of thermonuclear synthesis [1], their radiation output L relates to their mass according to

$$L \cong k.m_s^3 \tag{2}$$

where the value

$$k \cong 5 \times 10^{-65} W.kg^{-3} \tag{3}$$

is attributed to the constant k. It follows from relations (1) and (2) that increasing the star mass, its radiation output grows more extensively than its gravitational pressure. A consequence is that star becomes unstable from the viewpoint of gravity at a certain limit mass $m_{s(max)}$. According to the literature data [1]

$$m_{max} \cong 20 m_{Sun} \tag{4}$$

where m_{Sun} is the present mass of our Sun. It is, however, worth mentioning that stars of a mass as high as

$$m_s \cong 60 m_{Sun} \tag{5}$$

have been observed by astronomers. One of the reasons of a given discrepancy may lie in uncertainty of the constant k value determination, further is an actual cosmological time of the star being observed (see relation (8)).

Results and discussion

In the model of Expansive Nondecelerative Universe (ENU) the density of gravitational energy is in weak field conditions localizable, independent on the system of coordinates (it depends on the radial distance only), and can be expressed as [2]

$$\varepsilon_g = -\frac{R.c^4}{8\pi.G} = -\frac{3m.c^2}{4\pi.a.r^2} \tag{6}$$

where ε_g is the density of gravitational energy emitted by a body with the mass m at the distance r, R denotes the scalar curvature (contrary to a more frequently used Schwarzschild metric, in the Vaidya metric $R \neq 0$ also outside the body), and a is the gauge factor. It is obvious that for a star to be stable, the absolute value of its gravitational output must be higher (equal in limiting case) than the value of its radiation output. It means

$$k.m_{max}^3 \leq \frac{d}{dt} \int \frac{R.c^4}{8\pi.G} dV \tag{7}$$

and, in turn

$$k.m_{max}^3 \leq \frac{m_{max}.c^2}{t_c} \tag{8}$$

where t_c is the cosmological time [3] reaching at present

$$t_c \cong 4.5 \times 10^{17} s \tag{9}$$

Relations (3), (8) and (9) lead to

$$m_{max} \leq \sqrt{\frac{c^2}{k.t_c}} \cong 30 m_{Sun} \tag{10}$$

The above result is in good accord with observations. Of course, observing (at the time being) very distant stars, i.e. seeing them as they were in a much shorter t_c, such stars may appear as more massive ones since the shorter t_c, the higher $m_{s(max)}$ (see relation 10).

We suppose there should be a dependence of the upper mass of stars and their cosmologic red shift.

References

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